

Analysis of Tuberculosis Casefinding in Denver, Colorado, 1965-70

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EARLY DETECTION of asymptomatic incipient disease is a basic tenet of preventive medicine. In following this tenet, the casefinding technique has been widely used. Casefinding, considered to be vital to any program of contagious disease control, was believed to afford significant benefits for both the individual and the general community.

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Mass screening by chest X-ray for pulmonary tuberculosis was developed during World War II, reached its heights in the early 1950's, and remains an integral component of many tuberculosis control operations. The followup of contacts, laws requiring laboratories to report positive cultures, school and Head Start skin testing programs, and routine prenatal skin tests have recently been initiated to complete the armamentarium for tuberculosis casefinding.

As the incidence of active pulmonary tuberculosis, however, began to decrease, there was a concomitant decrease in the yield of screening programs. In 1957, the Public Health Service recommended that mass radiographic efforts be deemphasized in areas where the incidence of tuberculosis was relatively low (white middle-class areas) and that efforts be concentrated on areas where the incidence was known to be high. Proponents could still be found for intensifying tuberculosis screening efforts, but other experts, such as Fleck (1), Bloomquist (2), and Brightman (3), began to question the efficacy of the mobile X-ray unit. In 1966, Ganem (4) noted that only 12.8 percent of all admissions to Massachusetts tuberculosis sanatoriums directly resulted from X-ray screening programs. With the ever-decreasing availability of health dollars for tuberculosis con-

trol programs, the value of casefinding has become increasingly questionable.

Denver, the urban core of a metropolitan area with 1.5 million people, has maintained an active tuberculosis casefinding program since 1949. Serious efforts to redirect the city's mobile X-ray units' activities were undertaken in 1965—with surprising results. Concomitantly, careful records were maintained as to the cost and effectiveness of these activities. We have analyzed the value, effectiveness, and cost of these tuberculosis casefinding efforts, focusing primarily on the X-ray program of the past 6 years (1965–70). In addition, we have analyzed how each active case of pulmonary tuberculosis documented in the period 1966–70 actually came to the attention of the Denver Department of Health and Hospitals.

1949 Mass Survey

In the spring of 1949, an ambitious attempt to obtain a chest X-ray on every person over 15 years of age was undertaken in the metropolitan area of Denver. All area health departments, medical societies, and tuberculosis associations cooperated in this survey and, through massive publicity, the campaign reached 69 percent of the residents over 15 years of age (5). Following is a summary of the results:

<i>Results</i>	<i>Residents</i>	
	<i>Number</i>	<i>Percent</i>
Satisfactory films.....	324,096	100.0
Active cases.....	322	0.1
Inactive cases.....	3,831	1.2
Total pathological conditions.....	8,184	2.5

Seventy-six percent of the white population, 60 percent of the Negro population, and 42 percent of the Spanish-American population participated in the survey. By age group, the percent of participation was as follows:

<i>Age group (years)</i>	<i>Percent participating</i>
All ages.....	69
15–19.....	89
20–24.....	86
25–34.....	78
35–44.....	71
45–64.....	62
65 and over.....	45

The results of the 1949 survey were as expected. More tuberculosis was found in males than in females. Minority groups had higher prev-

Table 1. Period since the 403 respondents in the 1965 Denver health survey and their spouses had chest X-rays from mobile unit

Period since last X-ray—	Percent of respondents			Percent of spouses
	21–44 years	45–64 years	65 years and over	
During past year.....	27	21	21	27
1–3 years ago.....	21	21	16	17
4–10 years ago.....	5	10	11	3
More than 10 years ago.....	2	3	1	1
Never.....	45	45	49	52

alence rates. There was more tuberculosis in geographic areas where the population was of low social and economic status. A definite rise in prevalence was found with increasing age. Most notable was that the higher tuberculosis rates were found in the age, sex, and racial groups that participated poorly in the X-ray survey.

The conclusion reached, based on the survey, was that casefinding should be continued but be used with precision. Efforts would need to be focused on those populations in which few members took advantage of the mass survey and in which a high incidence of tuberculosis was discovered. Casefinding among older age groups was also to be stressed.

1965 Study of Years 1962-64

An evaluation of the results of operation of the mobile unit through the years 1962–64 revealed a 0.02 percent yield of new active cases of pulmonary tuberculosis. A review of the operation revealed a basic incongruity in the approach to tuberculosis casefinding. Despite the conclusions from the 1949 survey, the mobile unit had spent a predominant portion of its operating time (more than 75 percent) in the years 1962–64 in middle and upper socioeconomic areas. Yet the rates for tuberculosis incidence continued to correlate closely with the economic condition of the census tracts (a fact determined by combining median school education, median family income, number of sound housing units, and number of persons per room). During the 3 years, the 10 census tracts that were rated as lowest in socioeconomic status housed 6.9 percent of Denver's population and accounted for 27 percent of the city's new active cases of tuberculosis. The overall new active case rate in these areas was 245 per 100,000, as compared with Denver's overall rate of 22 per 100,000.

In 1965, the city health department completed a health survey of 403 of 450 randomly preselected families living in the 10 socioeconomically depressed census tracts. Responses to questions about the length of time since the respondent and the respondent's spouse had last obtained a chest X-ray from the mobile unit showed that more than 45 percent of these persons had never visited the mobile unit (table 1).

On the basis of these results, the activities of the mobile unit were confined for 6 weeks to these 10 census tracts of lowest socioeconomic status. Sites for the unit's operation were carefully selected to assure residents of each census tract easy access. Hours were adjusted to keep the unit open from 7 a.m. to 7 p.m., and program leaders attempted to motivate residents to participate in the campaign by actively involving their community leaders, church groups, local radio stations, "block gossips," and schools.

During that 6-week campaign, 2,131 persons were X-rayed. A check, however, of the place of residence given for each person screened revealed that only 22.3 percent lived within the poverty area. In fact, there was an inverse relationship between the census tract's rank in incidence of tuberculosis and the extent of participation of its residents. To compound the program's failure, 59.3 percent of the total group seeking X-rays had been X-rayed within the preceding 3 years. Our results (table 2) confirmed the report in 1954 of Anderson and co-workers (6) that emphasized the reluctance of lower socioeconomic groups to participate in tuberculosis screening.

In a final attempt to use PFX (photofluoroscopic X-ray) screening units as survey tools,

stationary units were installed in all health facilities serving the lower socioeconomic census tracts. These facilities were the Denver General Hospital's outpatient department, the Eastside Neighborhood Health Center, and the Ave Maria Clinic (the latter a service provided in the poverty area by Denver's Catholic hospitals). The staffs of all facilities were willing to participate when they were assured that every X-ray taken would be individually placed in an envelope and stapled to the patient's health record, thus giving the health provider a valuable baseline record. All of these outpatient facilities required financial screening upon a person's entry into the system and annual financial screening of all participants under their care. By requesting an X-ray at the time of financial screening, we believed that the procedure would be accepted by the people as part of their medical care while at the same time tuberculosis screening could be extended to a large segment of the poverty population. The mobile unit was reassigned to meet the psychological demands of more highly motivated persons and permanently stationed at the Denver City and County Building.

Analysis of 1965-70 Casefinding

Method. Tuberculosis casefinding in the Denver metropolitan area is conducted jointly by the Denver Disease Control Service of the Denver health department and the local Tuberculosis and Respiratory Disease Association. The disease control service keeps detailed budgetary and statistical records. Records of the Tuberculosis and Respiratory Disease Association, while not as detailed, are adequate for determining costs.

Budgets for programs and records of expenditures were used in the cost analysis of the X-ray screening program. The costs included the initial expense and depreciation of individual photofluoroscopic X-ray units, salaries of X-ray technicians and a receptionist, a percentage of the administrative overhead, and a percentage of costs of the disease control clinic. The costs of this clinic, which serves the entire metropolitan area, included the salary of a clerk typist providing followup on abnormal X-ray results, the costs of film and chemicals for processing it, 25 percent of the salary of the assistant director, who is responsible for reading the PFX films, 10 percent of a clerical supervisor's salary, the costs of postage, and 25 percent of the salary of an X-ray technician who develops and processes all films. The percentage contributed by each X-ray unit was obtained by

Table 2. Participation in 1965 X-ray program by residents of 5 census tracts in Denver ranking highest in tuberculosis incidence

Rank in incidence	Total X-rays	Census tract residents X-rayed		Percent of total participants not X-rayed within 3 years
		Number	Percent	
1.....	397	49	12.3	46.4
2.....	158	24	15.2	50.6
3.....	501	79	15.8	44.5
4.....	344	92	26.8	40.5
5.....	731	209	28.6	33.0

NOTE: The 1965 program was limited to the 10 census tracts of lowest socioeconomic status.

determining the fraction of the total cost that was equal to the fraction of the total number of films taken by each individual unit. Percentage yields and costs per case were then computed.

Overhead for the facility was not taken into account because each location provides for other important functions aside from housing the PFX units, and these costs would accrue whether or not the PFX program existed. Nor did we include the cost of the workup of suspected cases following their identification on a 14- by 17-inch film.

Public schools, parochial schools, and Head Start classes were included in the cost analysis of the school skin testing programs. Tine tests have remained at a steady \$46 per 250 units. The city's public schools do tine testing as part of seventh or eighth grade science classes; hence, the cost includes the nurses' time for planning, informing teachers and pupils about tuberculin tests, watching the test being given, interpreting it, following up on persons with positive results, recording, and reporting. The average time for these duties has varied but has remained around 30 hours per year (except for the 1968-69 school year, in which the nurses' time doubled because of an increased workload). School nurses have averaged around \$6.60 per hour over the past 5 years.

The cost analysis of the parochial school screening was based on the costs of the school nurses' and specialized nurses' time, payments for mileage, and expenses for nurses' home visits and equipment. The cost for the parochial school program in 1966-67 was reported by Sbarbaro (7) as \$1,800; the average cost was 56 cents per child tested. A 6 percent annual inflationary increase was presumed in calculating yearly parochial school screening costs.

Screening costs for Head Start included those for the public health nurses' time used in transportation and in applying and reading the tine tests and the cost of testing material. These costs were estimated by public health administrative personnel to average 52 cents per child tested.

The prenatal screening program provides tine tests, a followup reading if the patient notices induration, and a Mantoux test if the induration is more than 4 mm. A previous cost analysis by personnel of the Neighborhood Health Program revealed a cost per patient of \$1.

In all skin testing programs, the number of persons with positive reactions has been so small that tine tests have purposely been overread to reduce the opportunity for false-negative results. The fol-

lowup costs for these tests were considered negligible, and they were not included in the cost analysis.

Reliable information regarding the cost of followup of patients' contacts was not available for the years 1966-69; hence, costs for followup could only be analyzed for 1970. These costs included those for identification of contacts and providing them with Mantoux tests. Seventy percent of all contacts identified were seen by a nurse of the disease control clinic. The nurse's time per patient averages 30 minutes with the inclusion of time for travel, discussion with contacts, and the application and reading of the skin test. Clinic nurses are paid \$4.50 per hour. The remaining 30 percent of contacts (predominantly casual contacts) are given skin tests by other clinic personnel. The cost per unit for this service is 91 cents for personnel time and material. Additional costs for this casefinding technique include those for transportation to and from the clinic for 40 percent of the contacts (\$2.50 per clinic visit) and a percentage of the administrative overhead.

The number of persons screened, the number of new active and inactive cases, total pathological conditions, and the total costs for each program during the 1965-70 study period were used in the cost analysis when available. Percentage yields and the cost per result were then computed from each program for comparison.

Results. Over the 6-year period 1965-70, the mobile photofluoroscopic X-ray unit took 103,371 satisfactory films and discovered 15 new active cases of pulmonary tuberculosis, for a yield of 0.01 percent. In addition, 327 new inactive cases were found—a yield of 0.3 percent. The total number of films revealing abnormalities (all tuberculosis cases plus other pathological changes) was 3,431—a yield of 3.3 percent. The 6-year screening program cost \$121,721; the average cost per active case of disease found was \$8,115. The average casefinding cost per inactive case was \$372; per case of tuberculosis of any kind, \$356; per film with abnormal results, \$35; and per satisfactory film taken, \$1.17.

These results compare closely with the yields and costs at PFX units of the Denver Disease Control Service, the outpatient department of the Denver General Hospital, and the Ave Maria Clinic (tables 3 and 4). The yields of the disease control service's unit from 104,228 satisfactory films was 0.02 percent (18 cases) for new active pulmonary tuberculosis, 0.03 percent for inactive

cases; and 2.4 percent for all pathological changes. At Denver General's unit, 0.01 percent of the persons screened who had satisfactory films were found to have active tuberculosis (five cases from 36,408 films); 0.2 percent, inactive tuberculosis; 1.8 percent, abnormal results. At the Ave Maria's clinic's unit, 0.04 percent had new active tuberculosis (1 per 2,775 satisfactory films); 0.1 percent inactive tuberculosis; 1.9 percent, abnormalities.

Yields and costs of screening that were more favorable than at these three PFX units were found at the Denver County Jail unit and the PFX unit at the Eastside Neighborhood Health Center. At the Denver jail unit, over the same 6-year period, 12 new active cases of pulmonary tuberculosis (0.05 percent—based on 25,919 satisfactory films) and 137 inactive cases (0.5 percent) were discovered. Tables 3 and 4 indicate that the jail unit's casefinding was not only inexpensive (67 cents per satisfactory film taken) but also produced high yields with low resultant costs (averaging \$1,448 per new active case found).

Although the cost of casefinding at the Eastside Neighborhood Health Center was greater (\$1.25 per satisfactory film), the center took fewer films and had a higher yield of pathological conditions. Over the 6-year period, this unit took 3,897 films and found three cases of active disease (0.08 per-

cent yield) and 10 new inactive cases (0.3 percent yield). Nevertheless, whereas the average cost per new active case was relatively low (\$1,625), other costs were comparable to those of the more expensive PFX units.

Over the years 1965–66 through 1969–70, no new active cases of pulmonary tuberculosis were discovered through tine testing programs in the Denver public and parochial schools. Data for Head Start were available only for the school years 1968–69 and 1969–70. The yield of children with positive reactions on the tine test (first and eighth grades) was 1.2 percent in the Denver public schools, 2.18 percent in the parochial schools, and 0.29 percent in the Head Start program. Total costs of the testing were \$1,740 for Head Start (\$174 per child with positive reactions), \$8,940 for the parochial schools (\$30 per child reacting), and \$10,398 for the Denver public schools (\$20 per child reacting). These results are summarized in tables 5–7.

For the year 1970, a total of 2,603 expectant mothers were given tine tests at the Denver General Hospital or at facilities of the Eastside Neighborhood Health Center. Thirty-two women had positive reactions to the Mantoux test (29 of whom accepted isoniazid prophylaxis), giving a yield of 1.2 percent with positive reactions. The cost of the program was \$2,603 (\$81 per person

Table 3. Tuberculosis cases and pathological conditions found by all screening units, 1965–70

Testing unit	Satisfactory films	Active cases		Inactive cases		Pathological conditions	
		Number	Percent	Number	Percent	Number	Percent
Mobile unit	103,371	15	0.01	327	0.3	3,431	3.3
Disease control unit	104,228	18	.02	266	.3	2,494	2.4
Denver General's financial screening unit	36,408	5	.01	70	.2	633	1.8
Ave Maria Clinic's financial screening unit	2,775	1	.04	3	.1	53	1.9
Eastside Neighborhood Health Center's financial screening unit	3,897	3	.08	10	.3	182	4.7
Denver County jail unit	25,919	12	.05	137	.5	900	3.5

Table 4. Cost analysis for all tuberculosis screening units, 1965–70

Testing unit	Satisfactory films	Total expenditures	Average cost per case found			Average cost per pathological condition identified	Average cost per film taken
			Active cases	Inactive cases	Active and inactive cases		
Mobile unit	103,371	\$121,721	\$8,115	\$372	\$356	\$35	\$1.17
Disease control unit	104,228	99,688	5,538	375	351	40	.96
Denver General's financial screening unit	36,408	34,625	6,925	495	417	52	.95
Ave Marie Clinic's financial screening unit	2,775	3,249	3,249	1,083	812	61	1.17
Eastside Neighborhood Health Center's financial screening unit	3,897	4,876	1,625	488	375	27	1.25
Denver County Jail unit	25,919	17,372	1,448	127	117	19	.67

reacting positively); no patients with active tuberculosis were found.

As expected, the best results were obtained from investigation of contacts of patients. During the years 1966-70, a total of 282 patients with active pulmonary tuberculosis reported their contacts, and 2,008 contacts were identified, of whom 906 (45 percent) were household contacts. Ninety-three percent of all contacts and 95 percent of household contacts were examined. Of those examined, 25 (1.3 percent) of the total contacts and 15 (1.7 percent) of the household contacts were found to have active pulmonary tuberculosis. While only 10 percent of these contacts with tuberculosis in both groups accepted prophylaxis, this percentage rose each year as prophylaxis was emphasized. The cost for the program of investigating contacts was \$2,790 in 1970. The average cost was \$9 per person examined, \$36 per person receiving prophylaxis, and \$399 per active case found.

Analysis of how tuberculosis cases came to the official attention of the Denver Department of Public Health revealed that over a 5-year period (1966-70), a total of 482 persons were documented as having active pulmonary tuberculosis. Of these 482 patients, 104 (21.6 percent) were reported by the private sector (private physicians and laboratories). City and State laws require all laboratories to report positive tuberculosis cultures immediately, and these laws are enforced by periodic review of the laboratories' books by the appropriate department of public health. Comput-

Table 5. Results of tine testing survey program in 8th grade of Denver public schools, 1964-70

School year	Total enrollment in grade	Percent tested and tests read ¹	Percent positive with reactions ¹	Cost of program	Average cost per reactor
1969-70	8,317	91	0.59	\$1,713	\$38
1968-69 ²	13,754	96	1.11	3,051	21
1967-68	7,583	79	.78	1,401	30
1966-67	6,829	78	2.06	1,267	12
1865-66	7,069	79	1.64	1,310	14
1964-65	7,500	76	1.38	1,656	21
6-year summary	51,052	.....	1.20	\$10,398	\$20

¹ Denominator is total 8th grade enrollment.

² In this school year, children in both the 7th and 8th grades were tested.

NOTE: These 6 years of testing uncovered no new active cases of tuberculosis.

Table 6. Results of tine testing survey program in Denver parochial schools, 1964-69

School year and grade	Total enrollment	Percent tested and tests read ¹	Percent with positive reactions ¹	Cost of program	Average cost per reactor
1969-70	2,949	63	.43	\$1,692	\$212
K and 1st	986	64	.16	.....	.....
8th	1,963	63	.56	.....	.....
1968-69	3,435	22	.13	521	521
K and 1st	(2)	.....	.....	.....	.....
8th	(2)	.....	.....	.....	.....
1967-68	3,183	65	.64	1,700	131
K and 1st	1,795	56	.40	.....	.....
8th	1,389	77	.85	.....	.....
1966-67	3,192	93	3.67	1,796	16
K and 1st	1,621	94	1.25	.....	.....
8th	1,571	93	6.19	.....	.....
		93	3.67	1,796	16
1965-66	3,470	92	3.90	1,804	14
K and 1st	1,873	90	2.00	.....	.....
8th	1,597	95	6.03	.....	.....
1964-65	3,207	82	1.47	1,391	36
K and 1st	1,701	75	.78	.....	.....
8th	1,506	90	2.10	.....	.....
6-year summary	19,436	.....	2.18	\$8,904	\$30

K—kindergarten

¹ Denominator is total enrollment of each category.

² Not available.

NOTE: These 6 years of testing uncovered no new active cases of tuberculosis.

Table 7. Results of Head Start tine testing survey program

School year	Total enrollment	Percent tested and tests read ¹	Percent with positive reactions ¹	Cost of program	Average cost per reactor
1969-70	1,700	96	0.36	\$851	\$142
1968-69	1,800	95	.23	889	222
6-year summary ²	3,500	96	.29	\$1,740	\$174

¹ Denominator is total enrollment.

² Data for Head Start were available for only the 2 school years.

NOTE: In neither year were any new active cases of tuberculosis found.

sory laboratory reporting thus accounted for 64 (61.5 percent) of the patients reported by the private sector. Of all 482 patients, 40 (8.3 percent) were reported by private physicians.

It should be noted that, of the total 482 patients, only 39 (8.1 percent) were found by survey techniques and 26 (5.4 percent) by investiga-

tion of patients' contacts. Thus, only 13.5 percent of all new active cases were found by organized screening or casefinding. Conversely, 86.5 percent of the total patients came to our attention because they or their physicians suspected active illness (table 8).

Discussion

Photofluoroscopic X-rays. The photofluoroscopic X-ray unit, which takes 70 mm. chest films on 300–400 exposure rolls, demonstrated its effectiveness for screening large populations during World War II. Stimulated by a need to rapidly screen large numbers of inductees, the military developed the PFX technique, and it was put to civilian use soon after the war. Through the years, the PFX unit, both stationary and mobile, has remained the mainstay of tuberculosis screening programs. Massive publicity for chest X-ray programs in the 1950's and the frequent forays of the mobile X-ray unit into the community appear to have created a strong psychological urge in many persons to obtain free chest X-rays annually.

The value of chest X-ray survey programs, however, has frequently come under scrutiny (1–3, 8–10). The decreasing incidence of tuberculosis and the emergence of new priorities for the health dollar have combined to raise questions about the effectiveness, purpose, and necessity of X-ray screening programs. Denver's 1949 and 1965 surveys revealed once again the difficulty of getting this program to high-risk populations. Professional lassitude, community fear, and general resistance to change all contribute to the problem.

The establishment of stationary units in the admission areas of all health facilities serving the socioeconomically depressed populations, combined with the automatic taking of a chest X-ray

at the time of a person's financial screening, were visualized as affording a productive source of unknown active pulmonary tuberculosis in this city. Analysis of the data, however, shows that two of the three X-ray units taking X-rays at the time of financial screening, the Denver General's outpatient department and the Ave Maria Clinic, yielded no more tuberculosis, active or inactive, and no greater number of overall pathological conditions than did the mobile or stationary X-ray units of the health department. Likewise, the cost of finding an active or inactive tuberculosis case was equally exorbitant at all these facilities. These observations on the low case yield and high case cost of these stationary units were slightly diluted by the discovery that the general public was using the Denver General unit when the location of the mobile unit was inconvenient.

Although the Eastside Neighborhood Health Center's unit appears to have been more productive, the results are deceiving. In spite of multiple attempts to obtain systematically an X-ray on each patient, the number of persons obtaining X-rays was nevertheless very small. Frequent observations revealed that the ever-increasing demands for medical care for acute conditions forced the health center's staff to be inattentive to prevention and screening procedures. Despite repeated encouragement by the center's administrators, the system never functioned well.

Programs directed at other specific segments of the population were likewise nonproductive. Yearly chest X-rays are required in Denver for all food handlers and school teachers. Food handlers were originally selected as a means of reaching the lower socioeconomic population, while teachers were selected as a part of a "child-centered program." Analysis of our data revealed no signifi-

Table 8. New active cases of pulmonary tuberculosis found by each survey program or source

Year	Total number new cases reported ¹	Percent found by—					Other sources ²
		X-ray	Investigation of contacts	Private physicians	Laboratories	Death certificates	
1970.....	87	6.9	8.0	8.0	12.6	4.6	59.8
1969.....	82	13.4	.0	7.3	6.1	1.2	72.0
1968.....	117	9.4	9.4	7.7	18.8	4.3	33.3
1967.....	92	8.7	7.6	7.6	17.4	2.2	56.5
1966.....	104	2.9	1.0	10.6	9.6	.0	76.0
5-year summary.....	482	8.1	5.4	8.3	13.3	2.5	62.4

¹ No new active cases were found through school skin tests.

² Chest clinics, tuberculosis wards, and transfers into Denver.

cant difference between the selected subgroups and the population in general in respect to active and inactive tuberculosis.

Our analysis revealed that it cost more than \$8,000 to discover a new active case on the mobile unit. Although the worth to the patient of finding his case of tuberculosis is inarguable, we must put the argument into the perspective of limited funds for tuberculosis control, of other priorities, and of the worth to society at large. On the basis of the data from investigations of contacts, the patients had an average of three household and four nonhousehold contacts. In analyzing the number of new active cases arising out of this pool of contacts, we find that it took 11 active cases to produce one other active case. This result compares favorably with Public Health Service projections and diminishes the importance of asking, What happens if that one new case is not picked up by X-ray?

Unquestionably, the PFX unit has outlived its primary purpose and has become a grossly inefficient means of detecting active pulmonary tuberculosis. Our results are comparable to those of Brightman (3), who found that X-ray screening programs contributed only 12.8 percent to the total new active cases of pulmonary tuberculosis reported annually, and those of Ganem (4), who found that such programs contributed only 10 percent.

It should be noted, however, that PFX programs also detect inactive pulmonary tuberculosis along with other pathological chest conditions. Ferebee estimates that more than 75 percent of the new active pulmonary tuberculosis in the United States arises from the infected pool. Other studies have documented that persons with inactive disease remain at the highest risk of development of active disease. Prophylactic treatment with isoniazid aimed at the pool of inactive cases would have a substantial effect on the yearly incidence of tuberculosis. Hence, if X-ray surveys were seriously seeking inactive tuberculosis (and assuring prophylactic followup), the continued existence of these programs could perhaps be justified. The success of such an approach obviously requires that a high percentage of the persons with newly discovered inactive pulmonary tuberculosis accept and complete an adequate course of prophylactic treatment.

The significant numbers of pathological conditions of the chest noted during X-ray surveys have frequently been cited to justify the continued op-

eration of PFX units. Moreover, such units have been included in multiphasic screening programs. Nevertheless, while persons with pathological changes of the chest are referred to their private physicians for followup, to determine whether or not they actually have sought followup care in significant numbers is most difficult, as well as whether the reported condition was already known to the physician and whether the persons benefited from the discoveries. Enterline (11) found no significant improvement in the longevity of persons who had been informed of their chest conditions (other than tuberculosis) as compared with the longevity of persons who were first told their chest films were normal but who were found to have abnormalities on subsequent readings.

Specialized programs conducted by photofluoroscopic X-ray units, such as the screening of inmates of the Denver County Jail, can be justified by combining their relative yield per cost expenditure and the epidemiologic importance of removing a contagious person from a captive and closed population.

Skin testing. As the incidence of tuberculosis continued to fall, the 1963 Task Force of the Tuberculosis Branch, Center for Disease Control, recommended the "child-centered" approach as a major step in freeing this country from the grasp of tuberculosis. It was assumed that by identifying and treating the infected of the upcoming generation, a major link in the progression of tuberculosis could be broken. Thus, in 1965, Denver entered into skin testing surveys with the goal of providing tuberculin tests to all school children in the Denver area upon their entrance in school and once again in the seventh or eighth grades. The tine test was used because of its simplicity of application. Followup testing with 5 tuberculin units of intermediate PPD-S (purified protein derivative) was to be automatic.

No cases of active tuberculosis were found in school children by this program. Although the rate of positive tuberculin reactors was low, the average 6-year casefinding cost of \$24 per infected child seemed to justify the testing program. In an attempt to make future programs more cost effective, we analyzed the infected children by school districts, but the rates in high and low socioeconomic areas did not differ significantly. Forced busing has recently further confused this issue, and the gratifying negative results for the Head Start group throw serious doubt on the future value of a socioeconomic distinction in the

distribution of tuberculosis. As priorities for the health dollar change, school skin testing programs that benefit so few will be difficult to defend when compared with immunizations, visual acuity tests, and so forth that can benefit larger numbers.

As predicted by the 1963 Task Force, we did not find any source cases to explain the infections of the children entering school. All infected persons were offered treatment and encouraged to take it. The influence of the private practitioner has confused our followup somewhat, but a recent tally indicates that more than 95 percent of the children who were documented as having a positive reaction to PPD (purified protein derivative) accepted isoniazid prophylaxis.

The prenatal skin testing program, although it has proved to be of no importance in finding cases of active tuberculosis, may become a model for tuberculosis control. In the group of expectant mothers, 1.2 percent had positive Mantoux reactions, of whom 90 percent accepted isoniazid prophylaxis. Only a small proportion, however, completed the entire course. The associated costs of \$1 per person tested and \$28 per positive reaction was most favorable in the light of the women's acceptance of this preventive medicine.

Investigation of contacts. Presently, investigation of contacts of patients remains the most effective casefinding tool (12, 13). Yet our results show that even examination of contacts with active disease cannot be expected to give high yields of cases of active tuberculosis. As long as the overall cost of the program is low (\$2,790 for 1970) and the efficiency somewhat high (seven new active cases in 1970), investigation of contacts can be accepted as a worthwhile method of finding tuberculosis cases.

As with all casefinding approaches, the concern in investigation of contacts is to discover not only active disease but the infected persons who will serve as the reservoir for the active tuberculosis of the future. Treatment with isoniazid prophylaxis was advised and offered to all household contacts of patients and to the patients' nonhousehold contacts whose reactions on the tuberculin test converted to positive. While 90 percent of the highly motivated prenatal patients accepted prophylaxis in 1970, only 27 percent of all the household contacts could be induced to accept primary prophylactic treatment. Of the household contacts with documented infections, we were able to convince all but three to accept prophylaxis. Eighty-eight percent of the infected nonhousehold con-

tacts accepted prophylaxis. These results indicate that a continued high priority should be given to control efforts with contacts of patients.

Private sources. The most fruitful means of monitoring new active tuberculosis among persons seeking care from the private medical community is by surveillance of private laboratories (table 8). Reporting by private physicians adds only a small percentage to the new active cases reported each year. There are several reasons for this low proportion. The population served by private physicians has a very low incidence of tuberculosis, and therefore private physicians have a low index of suspicion. Moreover, private physicians are reluctant to report tuberculosis to public health authorities. That they fail to report is supported by our observation that private laboratories account for a greater percentage of the reporting (13.3 percent of all new cases reported from 1966 through 1970 as compared with 8.3 percent reported by private physicians). These results strongly support the rationale for laws requiring laboratory reporting.

A review of our data makes it clear that persons harboring active pulmonary tuberculosis soon develop symptoms, present themselves to a physician, and are found to have active pulmonary tuberculosis. The overwhelming percentages of active disease contributed by sources other than organized X-rays, skin testing, or investigation of patients' contacts show that active screening plays only a minor role in tuberculosis control; the patient's symptoms and the physician's index of suspicion play the major one.

Therefore, the continuation of organized tuberculosis casefinding by X-ray or skin test surveys seems justified only because effective mass screening campaigns have created in many persons an intense psychological desire to obtain their regular free X-rays. While this motivation was valuable in the early days of tuberculosis control, it now creates a powerful force that can perpetuate a costly and ineffective system. Undoubtedly, as agencies begin to phase out some of these methods, these psychological desires will have to be redirected to more worthwhile health measures.

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All tuberculosis screening and casefinding programs conducted in Denver, Colo., over the years 1965-70 were analyzed in terms of cost effectiveness. A random survey in 1965 revealed that 45 percent of the residents in census tracts with a high incidence of pulmonary tuberculosis had never had a photofluorogram from a mobile unit. Concentrated followup with mass casefinding efforts directed at these high-incidence areas resulted in a complete failure because the target population did not respond.

Cost analysis of all PFX (photofluoroscopic X-ray) units for the years 1965-70 revealed a yield of 0.01 percent of new active disease at an average casefinding cost of \$8,115. Inactive tuberculosis was found in 0.3 percent of

the persons X-rayed and at an average casefinding cost of \$372. Abnormal conditions, as indicated by X-ray, were found at a rate of 3.3 percent and at an average cost of \$35.

Skin testing programs for children entering school and for eighth graders were nonproductive, and the costs averaged \$30 per parochial school child reacting to the tine test and \$20 per parochial school child reacting. Rates of infection are decreasing to the point where the value of continuation of such school testing programs is questionable.

Selective casefinding directed at high-risk categories, such as pregnant women, can be justified by the high proportion of such persons offered preventive INH (isoniazid) therapy who accept

it. Of the pregnant women selected who were offered it, 90 percent accepted. Examination of the contacts of persons with active pulmonary disease was the most productive casefinding activity; 1.7 percent of household contacts and 1.3 percent of total contacts were found to have pulmonary tuberculosis.

Compulsory laboratory reporting of positive tuberculosis cultures accounted for 61 percent of the cases diagnosed by private practitioners that came to official attention. Overall, only 13.5 percent of all new active cases were found by organized screening or followup of contacts; 85 percent came to official attention because the patients or their physicians suspected tuberculosis, usually because of symptoms.